

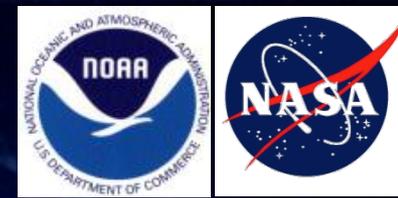
GOES-R AWG Product Validation Tool Development

Sea Surface Temperature (SST) Team

Sasha Ignatov (STAR)



SST Cal/Val Team



- **Prasanjit Dash:** SST Quality Monitor (SQUAM;
<http://www.star.nesdis.noaa.gov/sod/sst/squam/>)
Working with **Nikolay Shabanov** on SQUAM-SEVIRI
- **Xingming Liang, Korak Saha:** Monitoring IR Clear-sky radiances over Oceans for SST (MICROS;
<http://www.star.nesdis.noaa.gov/sod/sst/micros/>)
- **Feng Xu:** In situ Quality Monitor (iQuam;
<http://www.star.nesdis.noaa.gov/sod/sst/iquam/>)



OUTLINE



- SST Products
- Validation Strategies
- Routine Validation Tools and Deep-Dive examples
- Ideas for the Further Enhancement & Utility of Validation Tools
 - get ready for JPSS and GOES-R
 - Include all available SST & BT products in a consistent way
 - keep working towards making iQuam, SQUAM, MICROS community tools (half way there)
 - Interactive display (currently, graphs are mostly static)
- Summary



Validation Strategies-1: SST tools should be...



- Automated; Near-Real Time; Global; Online
- QC and monitor in situ SST
 - Quality non-uniform & suboptimal
- Heritage validation against *in situ* is a must but should be supplemented with global consistency checks using L4 fields, because in situ data are
 - Sparse and geographically biased
 - Quality often worse than satellite SST
 - Not available in NRT in sufficient numbers
- Satellite brightness temperatures should be monitored, too
- Monitor our product in context of all other community products



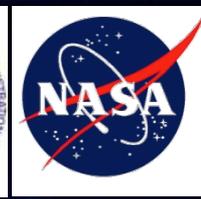
Validation Strategies-3: Global NRT online tools



- **In situ Quality Monitor (iQuam)**
<http://www.star.nesdis.noaa.gov/sod/sst/iquam/>
 - QC in situ SSTs
 - Monitor “in situ minus L4 SSTs”
 - Serve Qced in situ data to outside users via aftp
- **SST Quality Monitor (SQUAM)**
<http://www.star.nesdis.noaa.gov/sod/sst/squam/>
 - Cross-evaluate various L2/L3/L4 SST (e.g., Reynolds, OSTIA), for long-term stability, self- and cross-product consistency
 - Validate L2/L3/L4 SSTs against Qced *in situ* SST data (iQuam)
- **Monitoring IR Clear-sky Radiance over Oceans for SST (MICROS)**
<http://www.star.nesdis.noaa.gov/sod/sst/micros/>
 - Compare satellite BTs with CRTM simulation
 - Monitor M-O biases to check BTs for stability and cross-platform consistency
 - Unscramble SST anomalies; Validate CRTM; Feedback to sensor Cal



Validation Strategies-2: Work with SST increments



- *Satellite & reference SSTs are subject to (near)Gaussian errors*

$$T_{SAT} = T_{TRUE} + \varepsilon_{SAT}; \quad \varepsilon_{SAT} = N(\mu_{sat}, \sigma_{sat}^2)$$

$$T_{REF} = T_{TRUE} + \varepsilon_{REF}; \quad \varepsilon_{REF} = N(\mu_{ref}, \sigma_{ref}^2)$$

where μ 's and σ 's are global mean and standard deviations of ε 's

- *The residual's distributed is near-Gaussian*

$$\Delta T = T_{SAT} - T_{REF} = \varepsilon_{SAT} - \varepsilon_{REF}; \quad \varepsilon_{\Delta T} = N(\mu_{\Delta T}, \sigma_{\Delta T}^2)$$

where $\mu_{\Delta T} = \mu_{sat} - \mu_{ref}$; $\sigma_{\Delta T}^2 = \sigma_{sat}^2 + \sigma_{ref}^2$

(if ε_{SAT} and ε_{REF} are independent)

- *If $T_{REF} = T_{in situ}$, then it is customary 'validation'.*
- *If $T_{REF} = T_{L4}$, and $(\mu_{ref}, \sigma_{ref})$ are comparable to $(\mu_{in situ}, \sigma_{in situ})$, and ε_{SAT} and ε_{REF} are uncorrelated, then T_{REF} can be used as a substitute of $T_{in situ}$ to monitor T_{SAT} ("consistency checks")*
- *Check T_{SAT} globally, for self- and cross-consistency*



SST products: Polar



- **AVHRR**
 - NESDIS ACSP0 (Advanced Clear-Sky Processor for Oceans, new)
 - NESDIS MUT (Main Unit Task; heritage SST system designed in 1980s)
 - NAVO SeaTemp (builds on MUT heritage)
 - O&SI SAF (Lannion, Meteo France)
- **MODIS**
 - ACSP0 MODIS (under testing)
 - U. Miami (MOD 28)
- **VIIRS**
 - ACSP0 VIIRS (under testing with VIIRS Proxy)
 - Contractor SST (IDPS)
- (A)ATSR (planned)
- AMSRE (planned)

**NESDIS Products*

***Partners' Products*



SST products: Geo



- **ACSP0 SEVIRI (prototype for GOES-R ABI; Ignatov)**
 - Regression
 - Hybrid
- **NESDIS Operational (Eileen Maturi) – in testing**
 - GOES
 - SEVIRI
 - MTSAT
- **O&SI SAF SEVIRI (Pierre LeBorgne, Meteo France) – in testing**
- **NAVO Operational – in testing**

**NESDIS Products*

***Partners' Products*



Routine Validation Tools

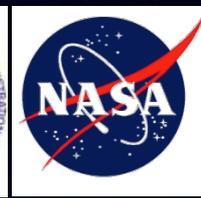


The SST Quality Monitor (SQUAM)

<http://www.star.nesdis.noaa.gov/sod/sst/squam>



Routine Validation Tools: SQUAM Objectives



- Validate satellite L2/L3 SSTs against *in situ* data
 - Use iQuam Qced SST in situ SST as reference
- Monitor satellite L2/L3 SSTs against global L4 fields
 - for stability, self- and cross-product/platform consistency
 - on a shorter scales than heritage in situ VAL and in global domain
 - identify issues (sensor malfunction, cloud mask, SST algorithm, ..)
- Following request from L4 community, L4-SQUAM was also established, to cross-evaluate various L4 SSTs (~15) and validate against *in situ* data



Routine Validation Tools: SQUAM Interface



NOAA NESDIS SST Quality Monitor (SQUAM)... Analyses of difference between satellite SST and analysis SST for timeseries stability & cross-platform consistency - Mozilla Firefox

http://www.star.nesdis.noaa.gov/sod/sst/squam/ Google

SST Quality Monitor

SQUAM v6.3

Home | Level 2 + | Level 3 + | Level 4 | About +

Last updated: Feb-28-2011

SQUAM objective

- Serve as a community tool for near real-time monitoring of major global SST products

What SQUAM does?

- Monitors global L2 & L3 SST products w.r.t. L4 fields
- Intercompares various global L4 SST products

Methodology

- Global QC and statistical checks for self- and cross-consistency using maps, histograms, time series, and dependencies of SST differences

Contact us

- Tell us how we can do better:
[Prasanjit Dash](#) [Sasha Ignatov](#)

Level-2	Level-3	Level-4
AVHRR GAC NESDIS MUT (heritage) NAVO SEATEMP NESDIS ACSP0 AVHRR FRAC NESDIS ACSP0 EUMETSAT O&SI SAF MODIS NASA MOD28/MYD28 (coming) NESDIS ACSP0 (coming) VIIRS (proxy) NGS/Raytheon IDPS (coming) NESDIS ACSP0 (coming)	AVHRR GAC NODC/RSMAS Pathfinder v5.0	Bulk Reynolds (AVHRR) : DO1_AV Reynolds (+ AMSRE-E) : DO1_AA RTG high resolution: RTG_HR RTG low resolution: RTG_LR NAVO K10 NESDIS POESGOES NASA JPL 1km G1SST: G1SST Foundation/Sub-skin OSTIA, UK MetOffice CMC 0.2°, Environment Canada ODYSSEA, MERSEA France Ensemble of L4 SSTs GHRSSST Median Ensemble
- "L2/3 vs L4" complements heritage "L2/3 vs insitu" validation ++Why? - Contributes to GHRSSST STVAL ++Link		- Contributes to GHRSSST IC-TAG ++Link

Highlights since June 2009

- In situ validation of [L4 SSTs](#) implemented [Dec-2010]
- SQUAM & other NESDIS monitoring systems presented at USSST meeting [Nov-08-2010] [PPT](#)
- Peer-review paper published in JAOT-Oceans [Nov-2010] [PDF](#)
- JPL G1SST and CMC 0.2° SST included in L4-SQUAM [Nov-03-2010] [More...](#)
- PathFinder v5.0 included in L3-SQUAM [Sep-03-2010] [More...](#)
- NAVO K10, GMPE, & POES-GOES Blended SSTs included in L4-SQUAM [Aug-23-2010] [More...](#)
- L4-SQUAM presented at GHRSSST-XI meeting [Jun-30-2010] [PPT](#)
- MetOp-A FRAC SST (NESDIS ACSP0 and O&SI SAF) included in L2-SQUAM [May-18-2010] [More...](#)
- NAVO SEATEMP products included in L2-SQUAM [Apr-07-2010] [More...](#)
- SQUAM presented at 2010 MyOcean & STVAL [Feb-23-2010] [PPT](#)
- L4-SQUAM referred by GHRSSST IC-TAG [Nov-30-2009] [Link...](#)
- L4-SQUAM set-up [Nov-13-2009] [More...](#)
- L2-SQUAM presented at GHRSSST-X meeting [Jun-5-2009] [PPT](#)



Routine Validation Tools:

SQUAM : ROUTINE DIAGNOSTICS



Tabs for analyzing ΔT_s (“SAT – L4” or “SAT – in situ”):

- ***Maps***
- ***Histograms***
- ***Time series: Gaussian moments, outliers, double differences***
- ***Dependencies on geophysical & observational parameters***
- ***Hovmöller diagrams***

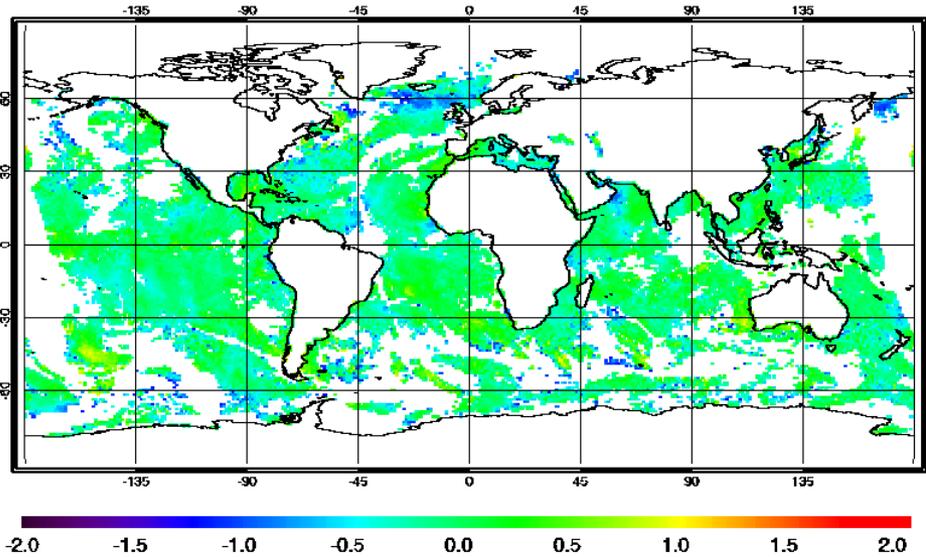
The SST Quality Monitor (SQUAM)
Journal of Atmospheric & Oceanic Technology, 27, 1899-1917, 2010



Routine Validation Tools: SQUAM : Maps, Histograms - Polar



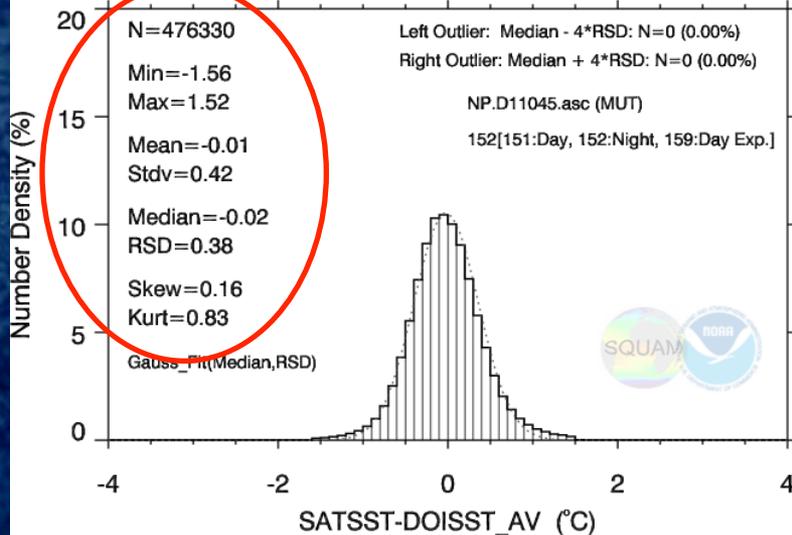
SST-OSTIA MetOpA 20110225 Night ACSPO V1.40



NESDIS Metop-A FRAC SST minus OSTIA

Maps are used to assess performance of global satellite SST "at a glance"

Feb 14 18:00:02 2011 to Feb 23 03:57:26 2011

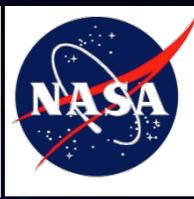


More FRAC analyses at:
<http://www.star.nesdis.noaa.gov/sod/sst/squam/FRAC>

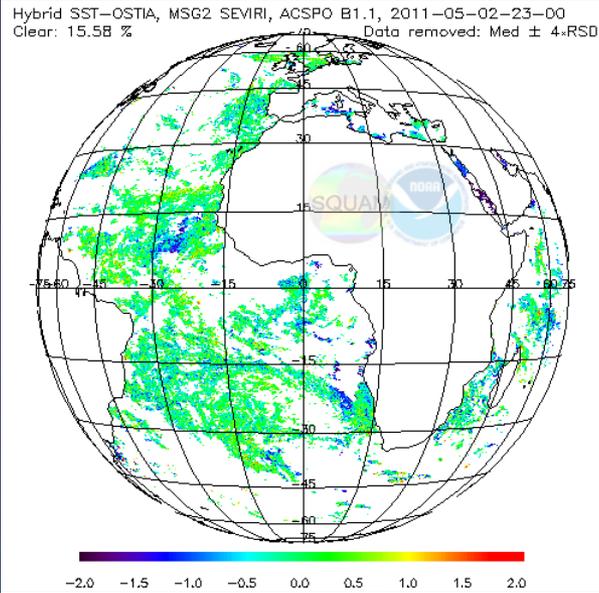
Gaussian parameters and outlier info are used in time-series plots



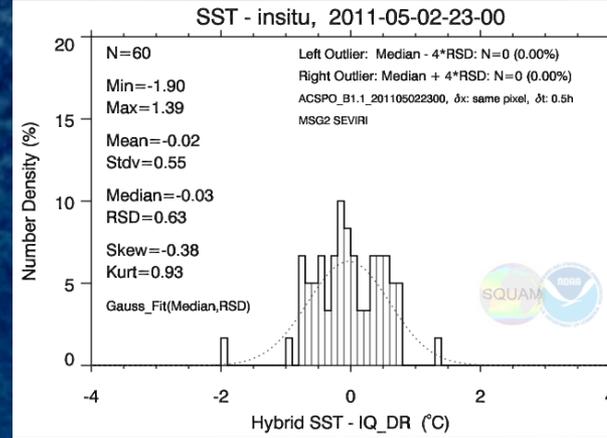
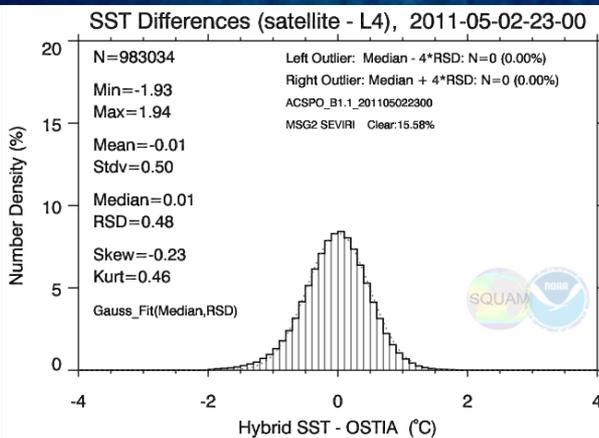
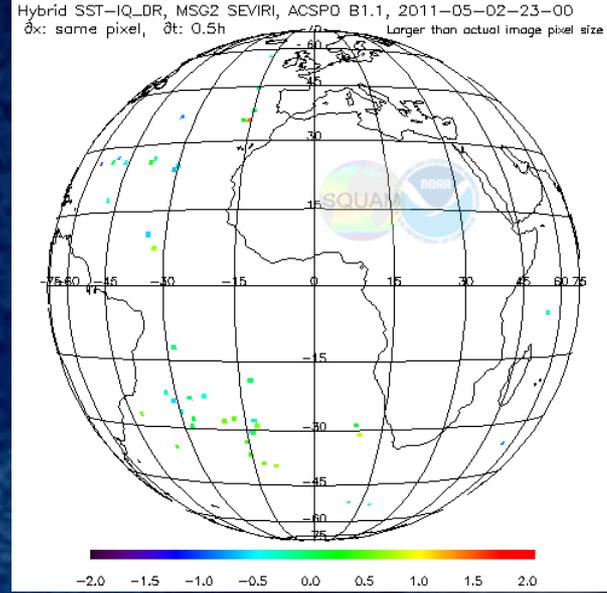
Routine Validation Tools: SQUAM : Maps, Histograms - SEVIRI



SEVIRI Hybrid SST - OSTIA

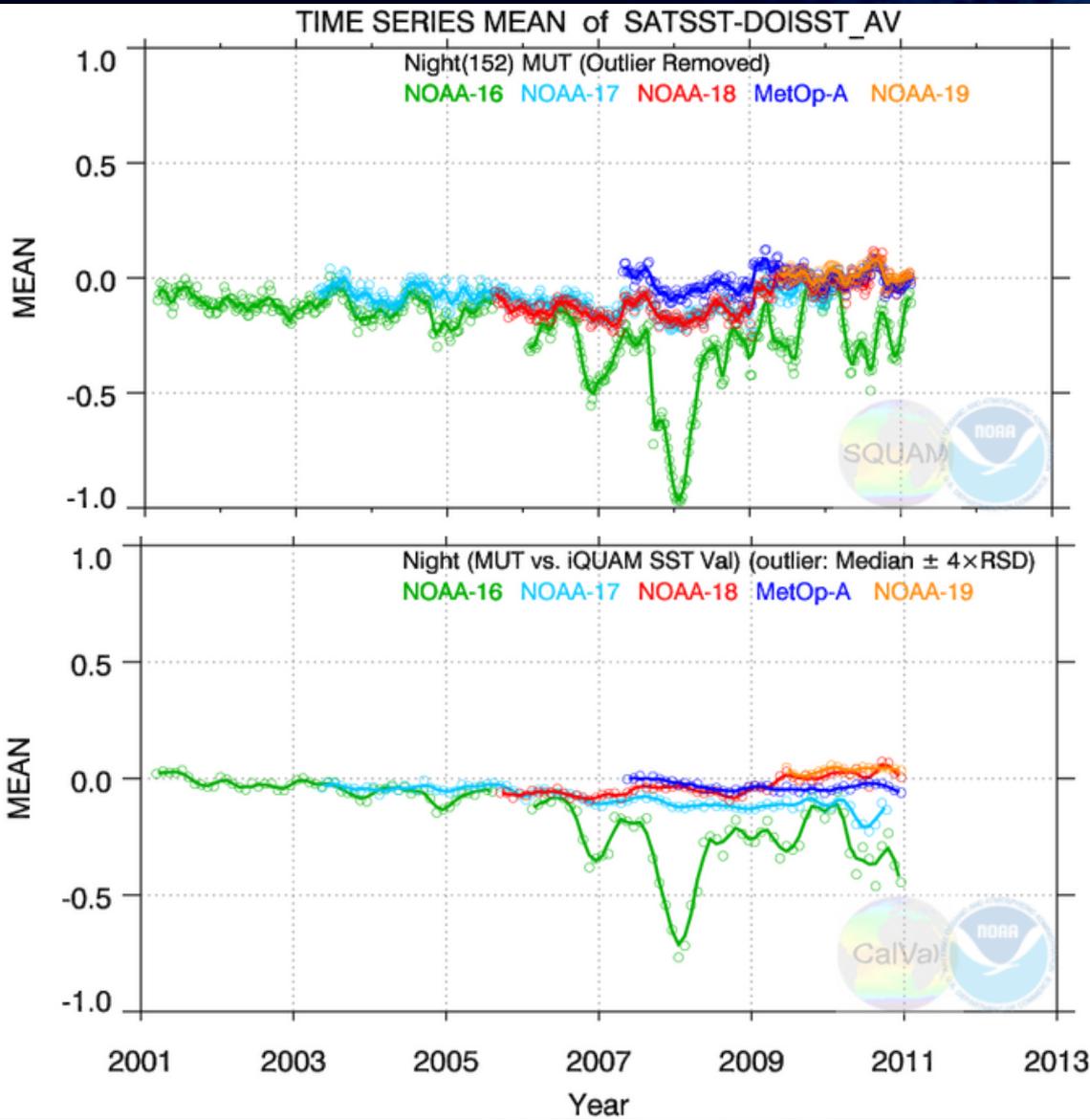


SEVIRI Hybrid SST - Drifters





Routine Validation Tools: SQUAM : Time Series - Polar



MUT AVHRR - Reynolds

*Night SST vs. Reynolds
(each point ~1 week)*

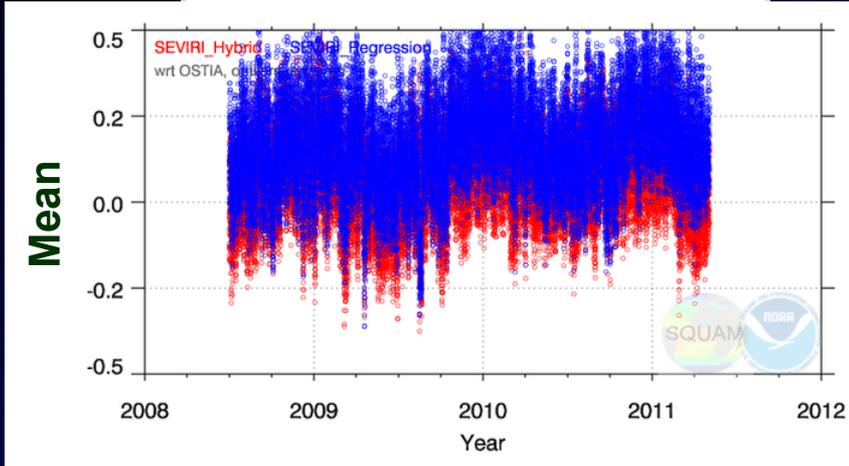
*Night SST val. Vs. in situ
(each point ~1 month)*



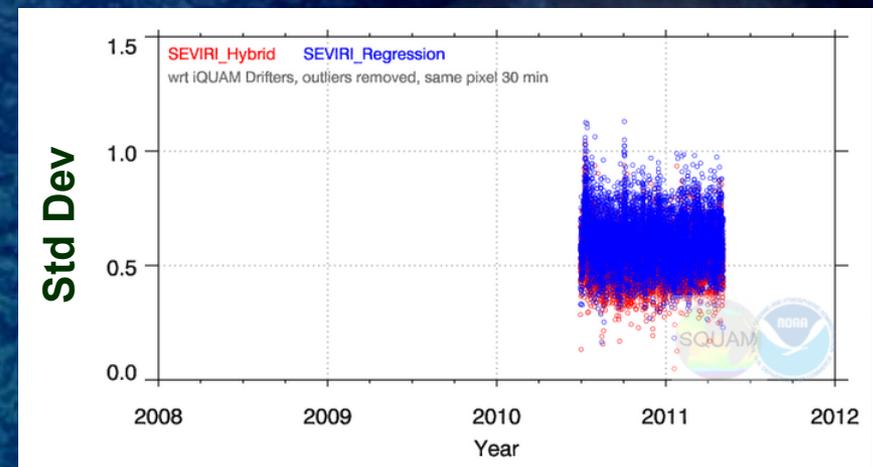
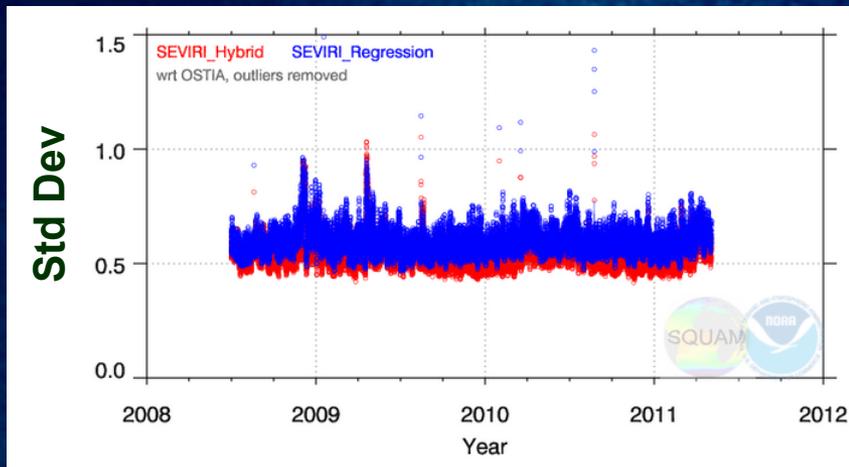
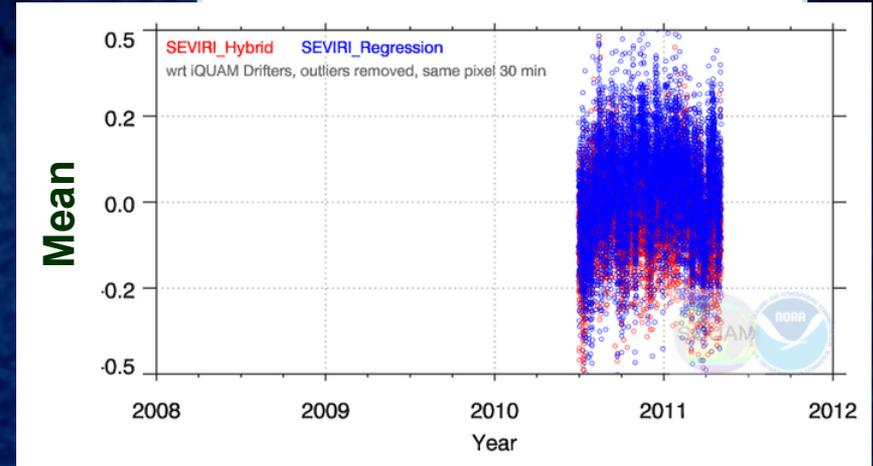
Routine Validation Tools: SQUAM : Time Series - SEVIRI



Statistics wrt. OSTIA



Statistics wrt. Drifters

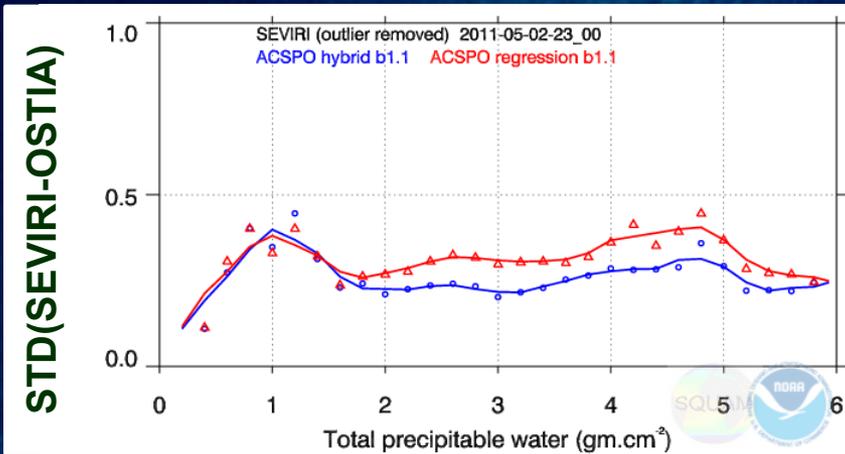
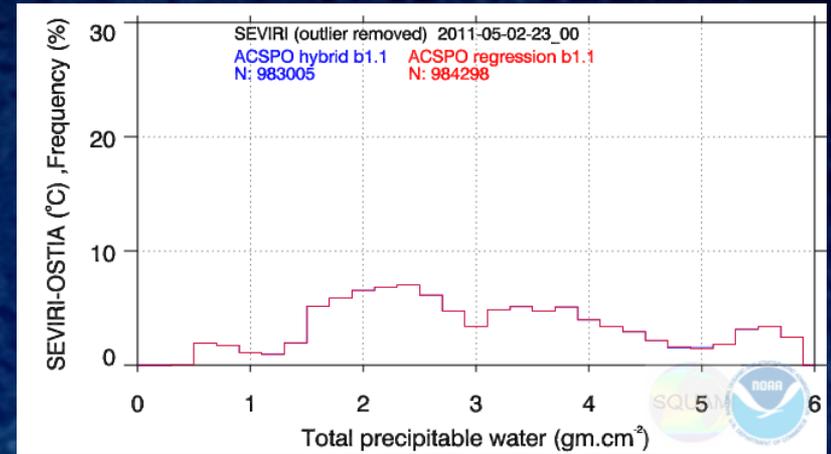
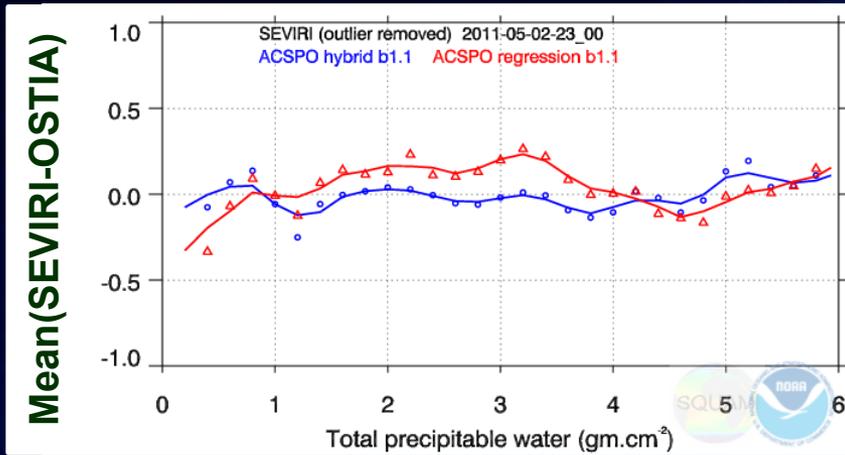


— Hybrid SST

— Regression SST



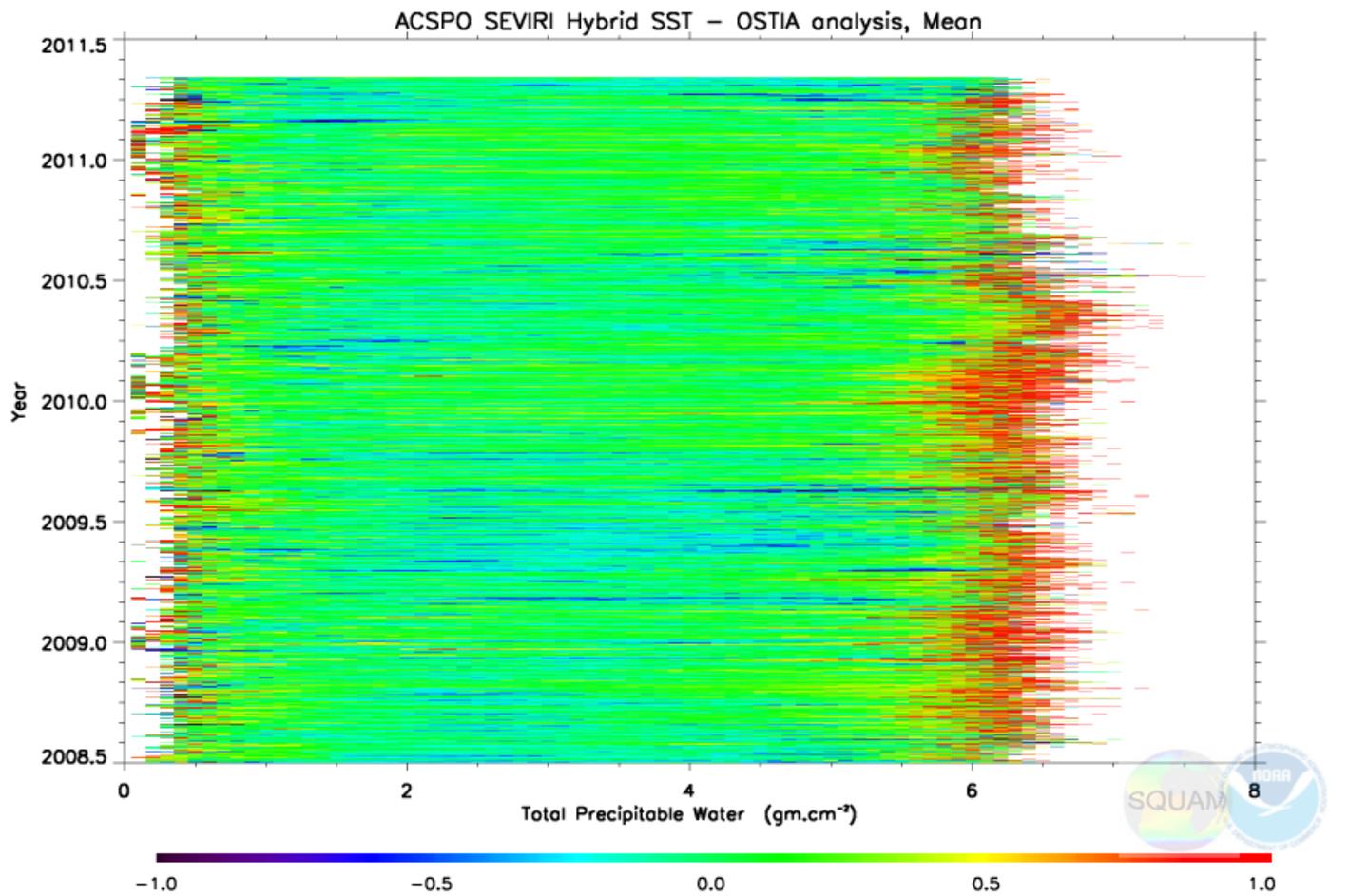
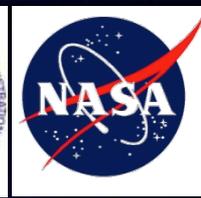
"Deep-Dive" Val. Tools : SEVIRI-SQUAM (Dependency plots)



Objective: Maximally uniform sample & performance across retrieval space



"Deep-Dive" Val. Tools : SEVIRI-SQUAM Hovmoller



Dependency of Hybrid SST vs. TPW.

More at SEVIRI SQUAM web:

<http://www.star.nesdis.noaa.gov/sod/sst/squam/SEV/>



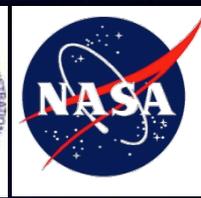
More on SQUAM



- Demo follows
- Publications
- Dash, P., A. Ignatov, Y. Kihai, and J. Sapper, 2010: *The SST Quality Monitor (SQUAM)*. *JTech*, 27, doi: 10.1175/2010JTECHO756.1, 1899-1917.
- Martin, M., P. Dash, A. Ignatov, C. Donlon, A. Kaplan, R. Grumbine, B. Brasnett, B. McKenzie, J.-F. Cayula, Y. Chao, H. Beggs, E. Maturi, C. Gentemann, J. Cummings, V. Banzon, S. Ishizaki, E. Autret, D. Poulter. 2011: *Group for High Resolution SST (GHRSSST) Analysis Fields Inter-Comparisons: Part 1. A Multi-Product Ensemble of SST Analyses (prep)*
- P. Dash, A. Ignatov, M. Martin, C. Donlon, R. Grumbine, B. Brasnett, D. May, B. McKenzie, J.-F. Cayula, Y. Chao, H. Beggs, E. Maturi, A. Harris, J. Sapper, T. Chin, J. Vazquez, E. Armstrong, 2011: *Group for High Resolution SST (GHRSSST) Analysis Fields Inter-Comparisons: Part2. Near real time web-based L4 SST Quality Monitor (L4-SQUAM) (prep)*¹⁹



Routine Validation Tools



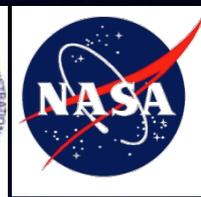
MICROS

Monitoring of IR Clear-sky Radiances over Oceans for SST

<http://www.star.nesdis.noaa.gov/sod/sst/micros>



Routine Validation Tools: MICROS Objectives



- Monitor in NRT clear-sky sensor radiances (BTs) over global ocean (“OBS”) for stability and cross-platform consistency, against CRTM with first-guess input fields (“Model”)
- Fully understand & minimize M-O biases in BT & SST (minimize need for empirical ‘bias correction’)
 - Diagnose SST products
 - Validate CRTM performance
 - Evaluate sensor BTs for Stability and Cross-platform consistency



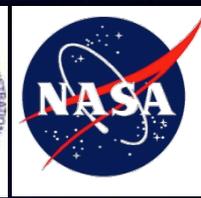
Platforms/Sensors monitored in MICROS



- Routinely processing AVHRR Jul' 2008-on
 - Metop-A (GAC and FRAC - Good)
 - NOAA19 (Good)
 - NOAA18 (Good)
 - NOAA17 (stopped processing 2/10; sensor issues)
 - NOAA16 (out of family)
- Under testing / In pipeline
 - VIIRS Proxy
 - MODIS (Terra & Aqua)
 - MSG/SEVIRI



Ways to present M-O Bias



MICROS Version 4.1
Monitoring of IR Clear-sky Radiances over Oceans for SST

References Links Acknowledgment People Updated: 4-8-2011

MICROS Home

Data Analysis

- Maps
- Histograms
- Time Series
- Dependencies

System Information

- Data Availability
- Data Download
- Version Update

Ch3B Night

Ch4 Day

Ch5

SST

Robust

Conventional

Maps

Histograms

Time series

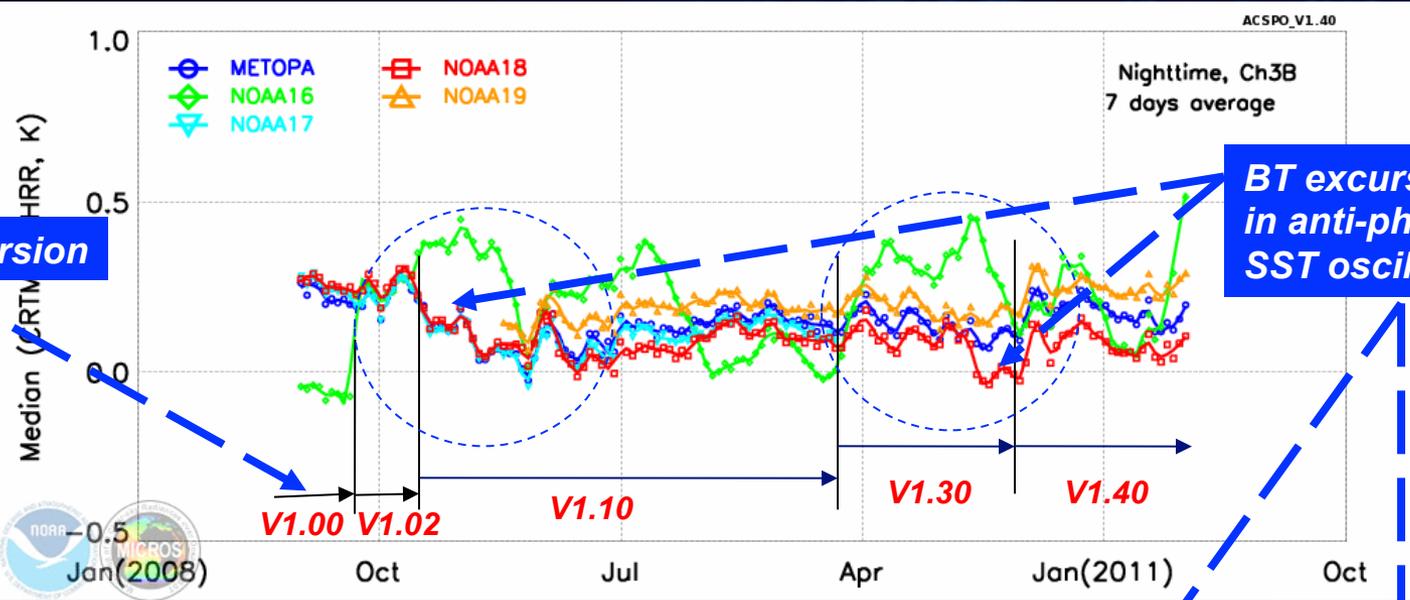
Dependencies

Four ways to present M-O Biases in MICROS



Routine Validation 1: Time series

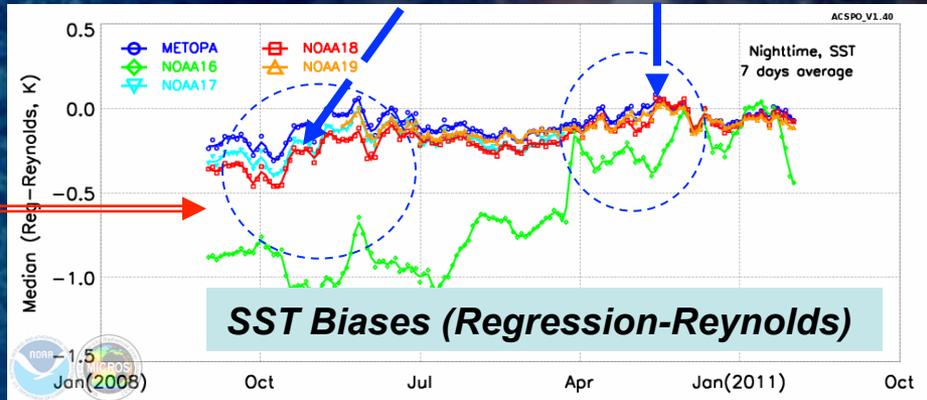
M-O bias in Ch3B



ACSPO version

BT excursions occur in anti-phase with SST oscillations

- Warm M-O biases: Combined effect of: Missing aerosols; Using bulk SST (instead of skin); Using daily mean Reynolds SST (to represent nighttime SST); Residual cloud.
- Unstable M-O biases: Due to unstable Reynolds SST input to CRTM.
- N16: Out of family/Unstable (CAL problems).
- N17: Scan motor spiked in Feb'2010.



SST Biases (Regression-Reynolds)



Routine Validation 2: Double Differences

Cross-platform consistency



- **Double-differencing (DD) technique employed to rectify the “cross-platform bias” signal from “noise”**

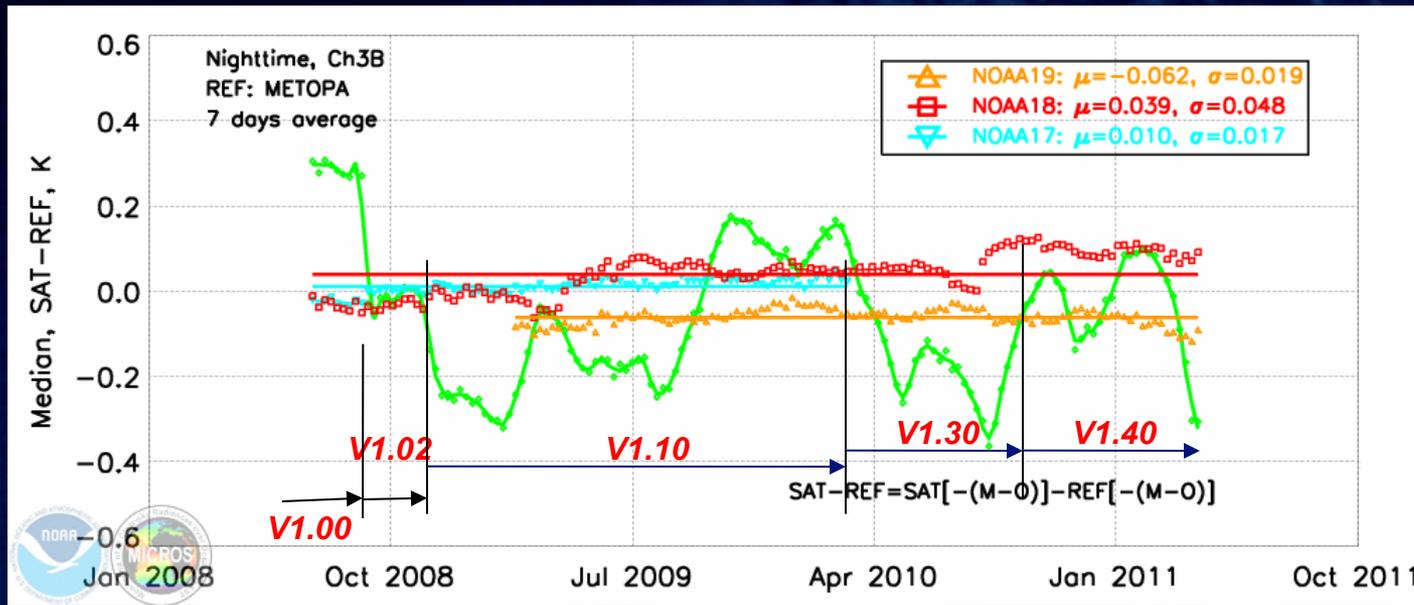
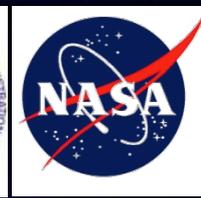
$$SAT - REF = SAT[-(M - O)] - REF[-(M - O)]$$

- **Metop-A used as a Reference Satellite (Stable)**
- **CRTM is used as a ‘Transfer Standard’.**
- **DDs cancel out/minimize effect of systematic errors & instabilities in BTs arising from e.g.:**
 - **Errors/Instabilities in reference SST & GFS**
 - **Missing aerosol**
 - **Possible systemic biases in CRTM**
 - **Updates to ACSPO algorithm**



Routine Validation 3: Double Differences

Cross-platform consistency in Ch3B



- **Metop-A used as a Reference Satellite (Stable)**
- **CRTM is used as a 'Transfer Standard'.**
- **DDs cancel out most errors/noise in M-O biases**
- **Relative to Metop-A , biases are**
 - **N17: $+0.01 \pm 0.02$ K (stopped working Feb '10)**
 - **N18: $+0.04 \pm 0.05$ K**
 - **N19: -0.06 ± 0.02 K**
 - **N16: unstable**



More on MICROS



- Demo follows
- Publications
- Liang, X., and A. Ignatov, 2011: Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS). JTech, in press.
- Liang, X., A. Ignatov, and Y. Kihai, 2009: Implementation of the Community Radiative Transfer Model (CRTM) in Advanced Clear-Sky Processor for Oceans (ACSP0) and validation against nighttime AVHRR radiances. JGR,114, D06112, doi:10.1029/2008JD010960.



Summary



- Three near-real time online monitoring tools developed by SST team
 - In situ Quality Monitor (iQuam)
 - SST Quality Monitor (SQUAM)
 - Monitoring of IR Clear-sky Radiances over Oceans for SST (MICROS)
- iQuam performs the following functions (ppt available upon request)
 - QC in situ SST data
 - Monitor Qced data on the web in NRT
 - Serve Qced data to outside users
- SQUAM performs the following functions
 - Monitors available L2/L3/L4 SST products for self- and cross-consistency
 - Validates them against in situ SST (iQuam)
- MICROS performs the following functions
 - Validates satellite BTs associated with SST against CRTM simulations
 - Monitors global “M-O” biases for self- and cross-consistency
 - “SST”: Facilitate SST anomalies diagnostics
 - “CRTM”: Validate CRTM
 - “Sensor”: Validate satellite radiances for stability & cross-platform consistency